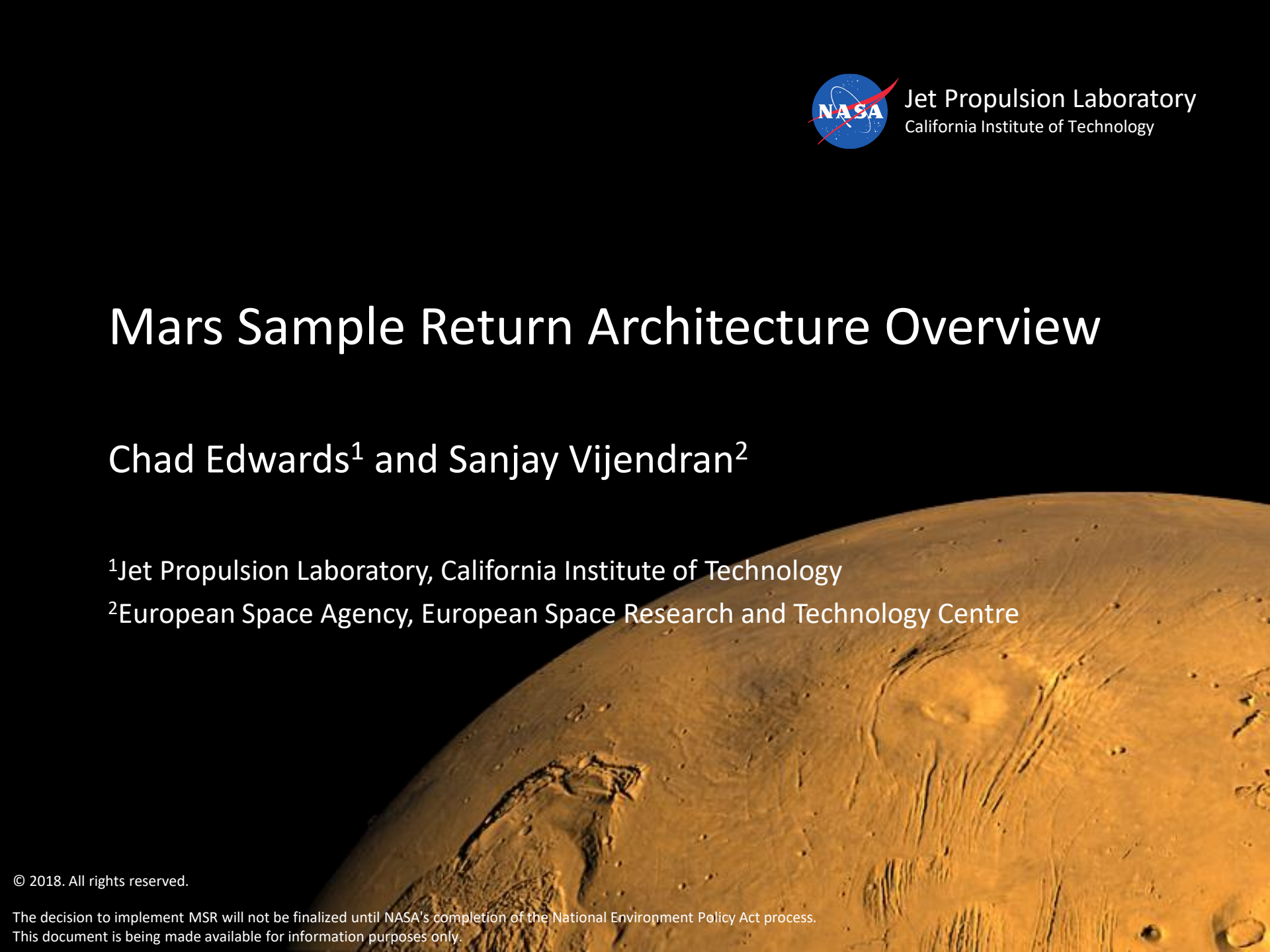


Jet Propulsion Laboratory
California Institute of Technology

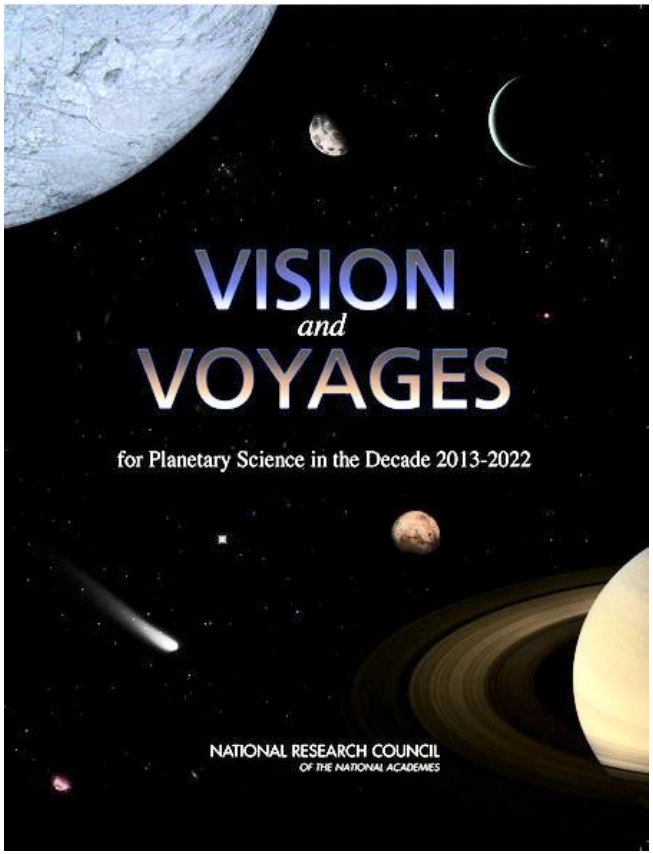
Mars Sample Return Architecture Overview

Chad Edwards[1] and Sanjay Vijendran[2]

[1]Jet Propulsion Laboratory, California Institute of Technology
[2]European Space Agency, European Space Research and Technology Centre

Mars Sample Return – a Decadal Survey Priority

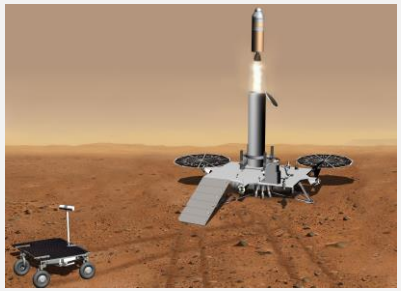
- ***The NRC Planetary Science Decadal Survey (2011) provided a strong recommendation for MSR***
  - "**The major focus of the next decade will be to initiate a Mars sample-return campaign**, beginning with a rover mission to collect and cache samples, followed by missions to retrieve these samples and return them to Earth."
  - "**A critical next step …. will be provided through the analysis of carefully selected samples** from geologically diverse and well-characterized sites that are returned to Earth for detailed study using a wide diversity of laboratory techniques"
  - "**The highest priority Flagship mission for the decade of 2013-2022 is MAX-C** (Mars astrobiology explorer-cacher)"
  - "During the decade of 2013-2022, **NASA should establish an aggressive, focused technology development and validation initiative** to provide the capabilities required to complete the challenging MSR campaign."



Notional Mars Sample Return Architecture (1/2)

- Three flight elements plus one ground element
  - Limits the cost, mass/volume, and technical challenges of each flight element

Sample Caching Rover (Mars 2020)
- *Sample acquisition and caching*



Sample Retrieval Lander
- *Fetch Rover*
- *Orbiting Sample container (OS)*
- *Mars Ascent Vehicle*

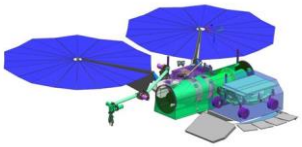
Earth Return Orbiter
- *Rendezvous and On-Orbit Capture System*
- *Earth Entry Vehicle*

Mars Returned Sample Handling
- *Sample Receiving Facility*
- *Curation*
- *Sample science investigations*

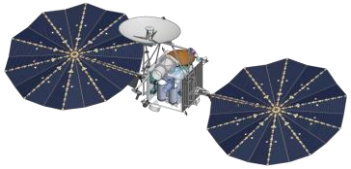
Flight Elements | ***Ground Element***

Notional Mars Sample Return Architecture (2/2)

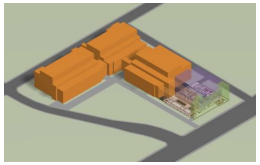
Sample Caching Rover (Mars 2020)



Sample Retrieval Lander



Earth Return Orbiter



Mars Returned Sample Handling

Flight

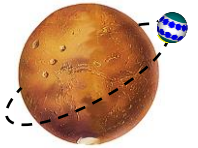
Ground

Launch from Earth/Land on Mars → Select Samples → Acquire/Cache Samples → Retrieve/Package Samples on Mars → Launch Samples to Mars Orbit *

Capture and Isolate Sample Container → Return to Earth → Land on Earth *

Retrieve/Quarantine and Preserve Samples on Earth → Assess Hazards → Sample Science

Sample Tube on Mars Surface



Orbiting Sample (OS) in Mars Orbit

Orbiting Sample (OS) on Earth

Sample Science

* Launching orders of MSR orbiter and lander can be reversed

MSR Campaign – Recommended Objectives

- Acquire and return to Earth a rigorously documented set of Mars samples for investigation in terrestrial laboratories
- Select samples based on their geologic diversity, astrobiological relevance, and biosignature preservation potential
- Document the field context for each sample based on in situ observations
- Ensure compliance with planetary protection requirements associated with the return of Mars samples to the Earth biosphere

Key MSR Cross-Element Interfaces

Returned Sample Tube Assembly

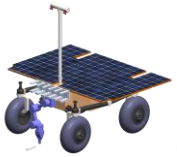
Orbiting Sample (OS)

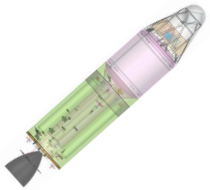
Earth Entry Vehicle (EEV)

Fetch Retrieval

OS Loading

MAV Launch

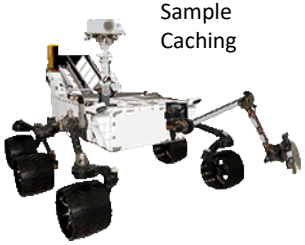


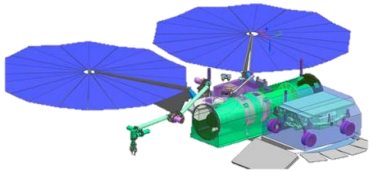


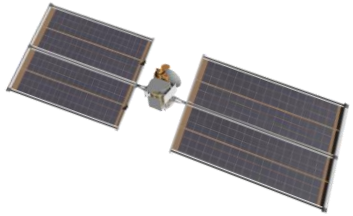
OS Rendezvous

OS CA/BTC, Txfr to EEV

Sample Caching







Mars 2020 Sample Caching Rover

Sample Retrieval Lander*

Earth Return Orbiter*

Mars Returned Sample Handling

*Concepts

Key Campaign-level Technical Trades

M2020 Sample Caching Strategy
- Depot(s)
- Add'l M2020 Extended Mission Caching?
- # Tubes
- M2020 Sample Tube Delivery?

SRL/ERO Joint Mission Timelines
- SRL/ERO Launch Dates
  - ERO chem vs. SEP propulsion
- SRL Surface Mission Timeline
- ERO Orbital RDV timeline
- ERO Relay Support to SRL?
- Earth return date

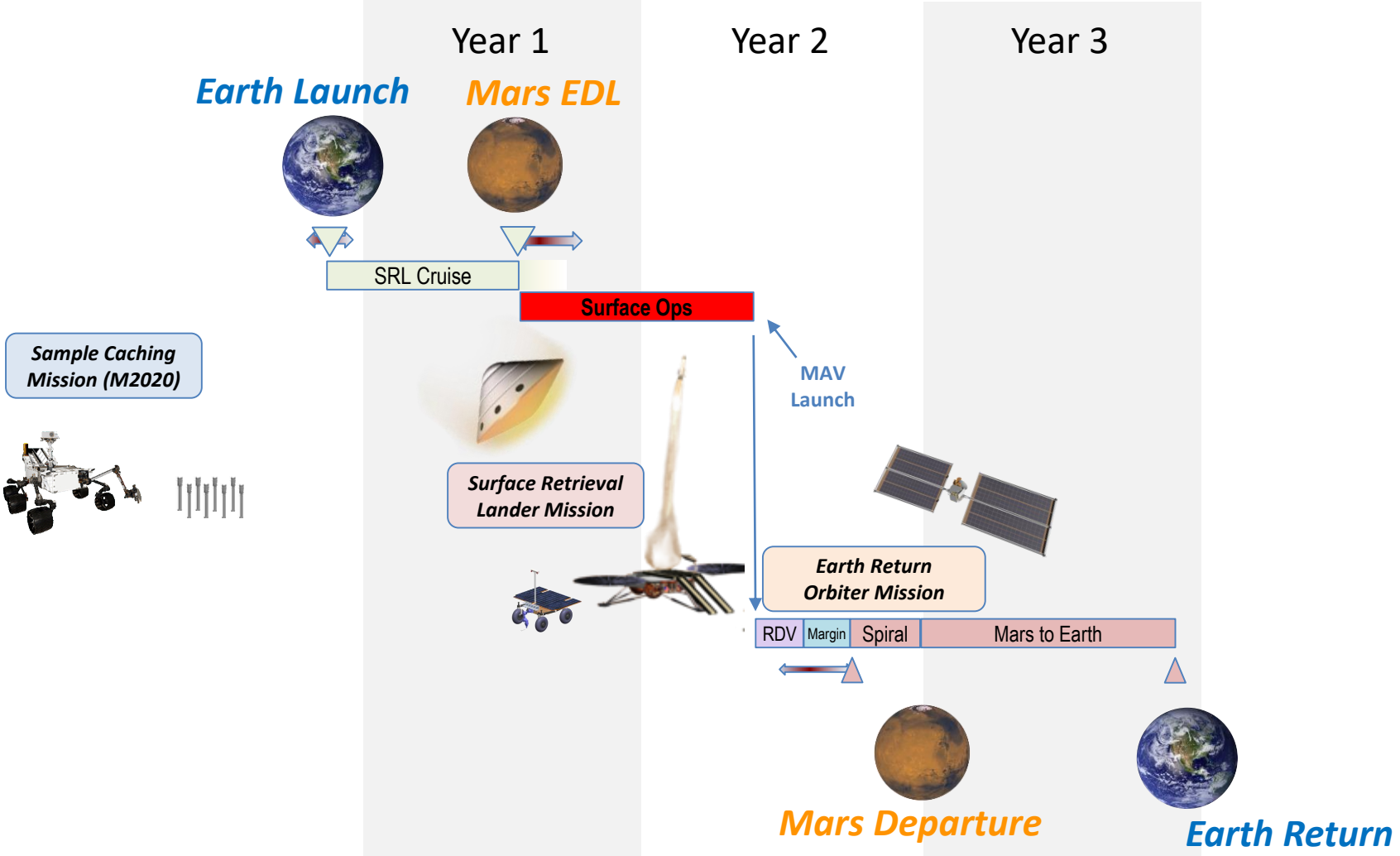
MAV
- Targeted Orbit (Altitude, Inclination)
- Delivered Orbit Accuracy

OS
- RF Beacon?
- # Tubes
- Air Samples?

Containment Assurance
- BTC on surface and/or in orbit
- CA method(s)

Earth Return Strategy
- Direct Earth Return
- Cis-Lunar Delivery w/ Crewed Return

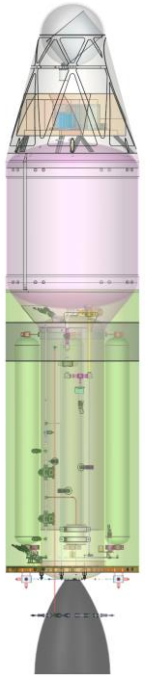
Notional “Fast” MSR Timeline



Fast timeline could return samples to Earth ~3 yrs after SRL launch

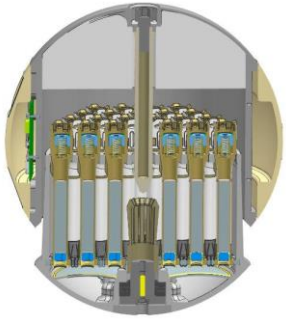
Key MSR Technology Needs

Sample Retrieval Lander



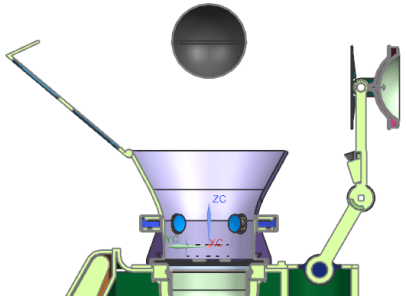
Mars Ascent Vehicle

Sample Fetch Rover

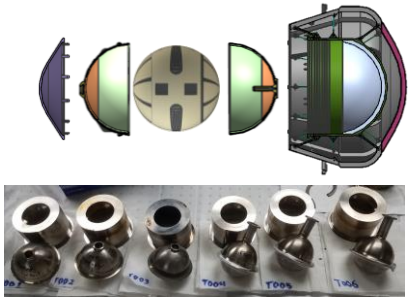


Orbiting Sample (OS) Container

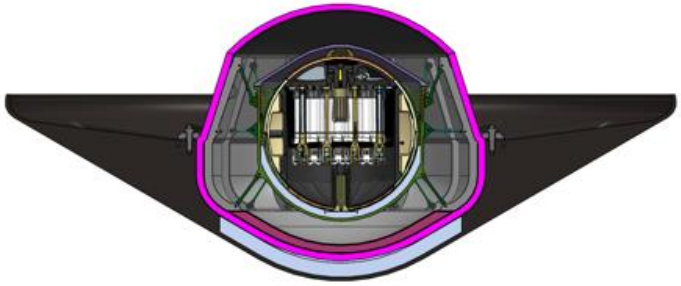
Earth Return Orbiter



Rendezvous and Capture



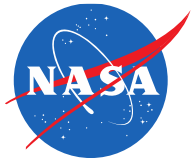
Containment Assurance



Earth Entry Vehicle

Forum: Concept for a Mars Sample Return Architecture, Flight Mission Elements, and Subsystems

Time	Title	Presenter
11:25	MSR Architecture Overview	C. Edwards
11:40 am	Mars Sample Return Lander Mission Concept	B. Muirhead
12:00 pm	ESA Sample Fetch Rover: Heritage and Way Forward	L. Duvet
12:15 pm	MSR Fetch Rover Capability Development at the Canadian Space Agency	V. Hipkin
12:30 pm	*Lunch*	
1:30 pm	Mars Sample Return — Earth Return Orbiter Mission Overview	S. Vijendran
1:50 pm	Mars Orbiting Sample (OS) Capture and Containment Technology Development	J. Parrish
2:05 pm	*Discussion*	
2:15 pm	*Live-stream of the ILA Berlin Air Show Mars Event*	
3:00 pm	A Maturing Earth Entry Vehicle Concept for Potential Mars Sample Return	S. Perino
3:15 pm	Planetary Protection Associated with Mars Sample Return	G. Kminek
3:35 pm	*Discussion*	
3:50	*Break*	



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Backup